19

New York University
Progress Report No. 4
Radio Transmitting Receiving and Recording System for Constant Level Balloon
[Section I]
April 2, 1947

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COLLEGE OF ENGINEERING
NEW YORK UNIVERSITY

PERSTARE ET PRAESTARE
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REPORT BY THE

ENGINEERING RESEARCH DIVISION

PROGRESS REPORT NO. ~~3~~ 4

Covering Period from March 1, 1947 to
March 31, 1947

RADIO TRANSMITTING, RECEIVING AND RECORDING SYSTEM FOR CONSTANT LEVEL BALLOON

Research Division, Project No. 93

Prepared in Accordance with Provisions of Contract
W28-099 ac-241, between
Watson Laboratories, Red Bank, New Jersey
and
New York University

Prepared by

Prof. Philip Greenstein
Project Director
Department of Electrical Engineering

Approved by Renato Contini

Renato Contini
Acting Director of Research

Research Division
College of Engineering
April 2, 1947

ABSTRACT

During the period covered by this report, work was continued on developing an FM transmitter. Tests were made on FM Radio Receiver R-2a/ARR-3 and Radio Transmitter T-1B/CRT-1 to determine their performance characteristics, and compare the results with the transmitter system under development.

Necessary field equipment was constructed and an antenna was erected in preparation for field testing of the completed AM transmitter. A duplicate model of the AM transmitter was constructed and built into a container with a battery pack and simulated signal circuit.

a. PERSONNEL AND ADMINISTRATION

No change

b. COMMUNICATIONS

None

c. GENERAL WORK UNDERTAKEN DURING THIS PERIOD

It was called to our attention by the Watson Laboratories, Oakhurst Field Station, that the FM radio transmitter T 1-b/CRT, which is a unit of Sonobuoy equipment AN/CRT-1, might have application in this project. Five of these transmitters were purchased from a surplus radio supply house. These units were tested for frequency stability under conditions of variation in plate and filament voltages. Deviation measurements were made at several values of plate voltage. These tests indicated that this transmitter would probably be unsatisfactory without a system of automatic frequency control. The receiver used with transmitter, R-2a/ARR-3, has an a.f.c. circuit incorporated. A receiver of this type was borrowed from the Oakhurst Field Station. Tests were conducted to determine the overall frequency drift which could be tolerated in the transmitter before returning became necessary. It was observed that as great as a ± 0.35 mc shift could be tolerated at the transmitter. Further tests on the transmitter showed that the frequency deviation varied with input plate voltage and that as the battery depreciated, an error would be introduced in any amplitude measurement. For a plate voltage change from 135 to 90 volts, a variation in detected amplitude of over 20% was observed.

Further tests on the FM transmitter being devdoped at this laboratory showed that the deviation was likewise a function of the applied plate supply voltage. This problem will have to be solved by improved circuit design before a suitable FM transmitter can be evolved.

In addition to the AM transmitter model already constructed, a second unit was built. This duplicate was installed in a cardboard container which also houses the storage battery supply and a blocking oscillator to supply an audio-frequency which modulates the carrier at 30 c.p.s. Plans and arrangements were made for testing this unit on a captive balloon.

d. APPARATUS

A battery box containing a metered circuit for constant monitoring of transmitter currents were constructed for field or blimp transmission tests.

An antenna approximately 150 ft. in length was erected on poles twenty feet above the roof of the Electrical Engineering Building for use in receiving signals during test flights.

e. FUTURE WORK

In view of the excellent characteristics of the automatic frequency control of the Radio Receiver R-2a/ARR-3, an attempt will be made to secure the circuit diagram of this equipment and employ its use in any FM receiver which might be used.

Further circuit investigation will be carried out to develop an FM transmitter which is free of the undesirable effects introduced by input voltage variations.

Field tests will be carried out on the AM transmitter using a tethered balloon and a blimp, if available. It is desired to obtain information about the operating range and difficulties which might develop with this transmitter.

Philip Greenstein

Philip Greenstein
Project Director

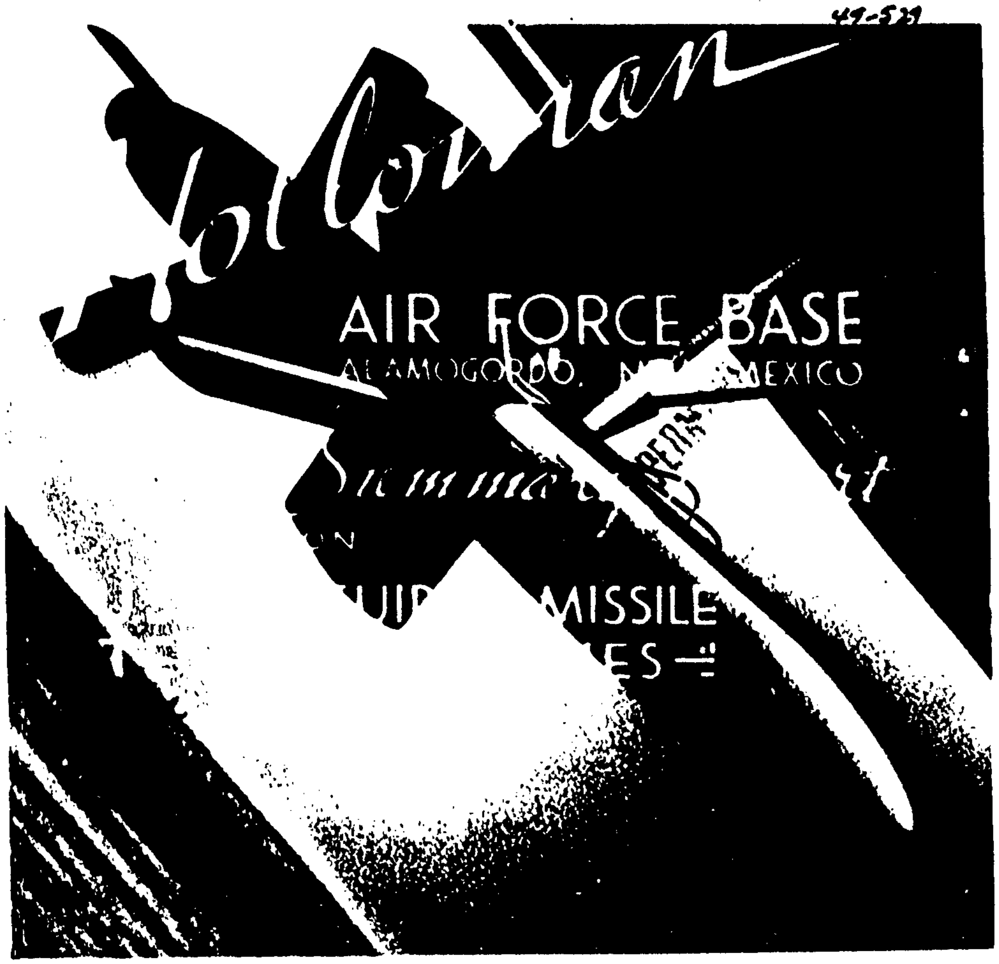
20

Interview
Col Jeffrey Butler and 1st Lt James McAndrew with Professor Charles B. Moore
June 8, 1994

Same as
Weaver Attachment 23

21

Report [Selected Pages]
Holloman AFB
"Progress Summary Report on
U.S.A.F. Guided Missile Test
Activities"
August 1, 1948



VOL. 1 1 AUG. '48 NO. 10
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HOLLOMAN AIR FORCE BASE
Alamogordo, New Mexico

PROGRESS SUMMARY REPORT

on

U. S. A. F

GUIDED MISSILE TEST ACTIVITIES

Compiled by:

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Major, USAF,
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S-E-C-R-E-T

Vol I   1 August 1948   No. 10

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radar station was not troubled by this phenomenon due to its antenna directivity and elevation orientation of 60 degrees. It is believed that the intermediate loss of signal by the radar station is normal because of elevation pattern lobing produced by ground-reflection interference which is initiated by secondary antenna lobe transmission. Since this condition exists in the transmitting pattern, it affects both the radar station and its remote receiving station. Current effort is concentrated on improvement of photography and antenna orientation in preparation for additional tests.

b. Tracking Projects:

(1) Radar Tracking Set AN/MPS-6 - A letter was received from Watson Laboratories authorizing changes and modifications of the range circuits necessary for conditions as encountered at this location. The fore part of July was spent in achieving these betterments, and in the installation and orientation of an M-2 optical tracker to be used in conjunction with the MPS-6 and as a tracking aid.

Experimental tracking of three balloons furnished and flown by the Atmospheric Group was performed for the dual purpose of checking the signal return of the radar with various reflecting targets, and for precise position data of the balloon equipment for use by the Atmospheric Group. On 19 July, a 130 foot balloon carrying no radar reflector was tracked. Radar contact was made at a range of about 3K yards with signal return being above saturation on the scopes of the MPS-6. Tracking was automatic in Azimuth and Elevation and aided in range. Signal return remained above saturation until a range of 7K yards was read, at which point grass appeared on the scopes and signal to noise averaged about 4 to 1 out to a range of 23K yards where too frequent radar losses necessitated that automatic tracking be abandoned. This balloon was then tracked manually to a maximum range of 27K yards.

On 20 July 1948, a weather balloon carrying one kite type reflector was flown and tracked. Contact was made at a range of 3K yards, and signal return was above saturation at all times until a range of 10K was exceeded and grass showed only occasionally out to 24,360 yards. This balloon was obscured by clouds at a range of 33K yards, but tracking was continuous in automatic Azimuth and Elevation throughout its flight, and the maximum range read was 34K yards.

On 21 July, a 130 foot balloon, identical with the one flown on 19 July except for three kite reflectors being carried, was flown and tracked. Radar contact was made at a range of 1,510 yards. Grass first appeared on scopes at a range of 24.5K yards, and signal was above saturation to 30K yards. Tracking was continuous and automatic throughout the flight, and a maximum range of 121K yards was reached.

Permission to use the MPS-6 in tracking further V-2 missiles having been received, plans were formulated for operation in conjunction with the missile scheduled to be fired Thursday, 22 July and postponed until Monday, 26 July at 1100. Plans contemplated that the crew on the M-2 Optical Tracker would track visually at all times during the flight with their elevation and azimuth readings repeated on the antenna. The MPS-6 antenna was initially positioned in azimuth on the calculated bearing to the launcher and raised slightly above the horizon in elevation, with the correct range gated on the scopes and with a velocity of about 300 MPH set in the aided range motor and the motor initially stopped. It was further planned that when target echo would bloom on the scopes, the echo should be trued up in Azimuth, Elevation, and Range; and antenna control would be thrown to automatic with range followed manually until speed of the missile approximated the 300 MPH as set on the motors, at which time the video motor would be activated and range tracking thrown to "Aided." It was planned to throw antenna control to the M-2 Tracker only if target failed to show or if extended "loss" subsequently occurred.

During the half-hour period prior to the take-off, several random aircraft were noted in the vicinity of the launcher; and at X-5 minutes, one low flying aircraft was observed on the scopes at a range beyond the launcher directly in line with it and flying in towards the launcher.

Timing signals and the zero signal were received, and at about X plus 2 seconds the target "bloomed" on the J Scopes at the calculated range to the launcher (62,800 yards). This pip went almost instantly to far beyond saturation, and all grass disappeared from the scopes. The Azimuth and Elevation, and Range controls were centered on the target, and antenna control was thrown to automatic. Range started to slowly increase as did elevation with azimuth being stationary. The echo remained beyond saturation for about two seconds after automatic control was thrown in, at which time grass appeared on the scopes and the signal fell rapidly to zero and the antenna whirled off target at about X plus 6 seconds. Upon returning antenna to position manually, a strong target appeared at a range of about 2K yards outside the range gate, and believing this to be the rocket, this pip was trued up and antenna locked in "Automatic" and this target was tracked for a period of about 10 seconds or until it was noted that range was decreasing and elevation was stationary at the horizon while the M-2 Elevation repeater showed the optical tracker to be looking at approximately 50 degrees. Realizing that the target being followed was the aircraft noticed before take-off, antenna control was transferred to the optical tracker and left in its control until the M-2 crew lost the missile. During this time, no target was visible at any time and no further radar contact was made with the missile. However, slightly before the missile impact was heard, a cluster of small echoes were found at a

22

Interview
[Col Jeffrey Butler and 1st Lt James McAndrew with] Col Albert Trakowski, USAF (Ret)
June 29, 1994

Same as
Weaver Attachment 24

23

Report
Cambridge Field Station, Air Materiel Command
"Review of Air Materiel Command Geophyscial Activities by Brigadier General D.N.Yates, and Staff, of the Air Weather Service"
February 10, 1949

[redacted]

[redacted] 47

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Review of Air Materiel Command Geophysical Activities by Brigadier General D. N. Yates, and Staff, of the Air Weather Service

Cambridge Field Station
Air Materiel Command
Cambridge 39, Massachusetts

~~23~~

PROGRAM

10 Feb. 1949

I. Introduction

II. Tour of Geophysical Research Laboratories

a. Review of Facilities

b. Project Presentations

III. Discussion

DOWNGRADED AT 12 YEAR INTERVALS; NOT AUTOMATICALLY DECLASSIFIED. DOD DIR. 5200.10

~~EXCLUDED FROM GENERAL DECLASSIFICATION SCHEDULE~~

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38

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[redacted]

PROJECT ABSTRACTS

I. TERRESTRIAL SCIENCES LABORATORY

Chief: Dr. James A. Peoples, Jr.

1. Project title: Acoustic Sounding of the Atmosphere

Project scientists: Dr. J. A. Peoples, Jr., Dr. Norman Haskell

Summary of In-Laboratory work:

When large explosions have occurred, it has been observed that the sound was heard locally, say up to 25 miles, and also at distances of 100 to 200 miles, but that nothing was heard at intermediate distances. This phenomenon can only be explained by assuming that the sound is refracted into the atmosphere over the intermediate observers and then is bent back down to the more distant areas. For this to occur the velocity of propagation must first decrease with altitude and then increase again to a value at least as large as ground velocity. This is due to a decrease of temperature up to the tropopause followed by an increase in temperature above that level. Winds also have an appreciable affect which can be determined from asymmetrical propagation.

Up to about 1946 most data on this phenomenon had been obtained by taking polls after accidental explosions had occurred. Zones of audibility were mapped out and general conclusions then drawn. Very little systematic work was done in which accurate travel times and other factors were obtained. Beginning in 1946 at these laboratories, a systematic study of these propagation anomalies were started. Sound ranging detectors were set up in arrays, so that the direction and time of arrival of compressional waves could be determined. Explosions were set off on or near the ground at ranges varying from 25 to 200 miles. Data has been taken which has resulted in the indirect determination of the temperature (sound velocity) structure of the atmosphere up to the stratospheric level. East-west propagation was first studied off the New Jersey coast. These tests show there is little or no regular diurnal variation, and that some annual variation in the temperature structure exists. High level winds are shown to be generally easterly. Additional tests have been made in New Mexico to determine the diurnal and annual variations of the temperature structure at that latitude. Some accurate observations of wind velocity are indicated by observations taken along a north-south line as well as an east-west line. Winter observations have been taken in the vicinity of Fairbanks, Alaska for information at very high latitudes. Observations have been taken near the Panama Canal Zone for additional information in the tropics.

The sounds produced by rockets launched at Alamogordo have been recorded with acoustic detector arrays located on the ground near the rocket trajectory. From data gathered in this manner, some indications of upper air temperature and winds have been obtained and much more accurate determinations could be made if the rocket trajectories were more accurately known.

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Additional details of the atmospheric temperature and wind structure can be obtained by placing microphones near the tropopause where the velocity of sound is at a minimum. To our knowledge, no one has ever tried such an experiment, and in order to do this new equipment had to be developed, since wind produces strong noise in any microphone it was obvious that the detectors could not be used on an aircraft, It was further believed that the noise level of an instrument placed on a constant level balloon would be far below that generally observed on ground equipment. Both a satisfactory constant level balloon and a light weight microphone and telemetering system has been developed in this laboratory.

Basic acoustic propagation information is now being accumulated from equipments launched at Eglin Field Florida. The sound for these experiments is obtained from high altitude (20,000 to 25,000 feet) bomb bursts. Sufficient data have not yet been obtained to justify complete analysis, but it can be stated that observed results generally agree with predictions based upon theory.

Observations of the travel times of waves from an explosive source has yielded a considerable amount of data on the temperature and wind structure of the atmosphere up to altitude of about 50 km (160,000 feet). The interpretation of the data has so far been based on geometrical wave theory, and leads to a variation of propagation velocity with altitude which is in reasonable agreement with other lines of evidence. There are, howecer, several observed facts which cannot be explained on the basis of the elementary geometrical ray theory, and require a more complete analysis in terms of wave theory. They are: --(1) the "zones of silence", that follow according to geometrical ray theory from the initial decrease of velocity with altitude, which do not have sharply defined boundaries; (2) the same apparent angle of arrival is often observed over a considerable range of distance from the source, whereas on the ray theory a given angle of arrival was associated with one particular distance only; (3) at large distances, the total duration of the signals recei is very much greater than can be explained by ray theory, and the character of the signal received is that of a long train of waves of varying amplitude and frequency rathe a limited number of well defined transient pulses.

Preliminary studies indicate that all of these facts may be explained qualatatively by more complete wave theoretical analysis of the diffraction of wave energy into the regions that are zones of silence in the elementary ray theory, and furth work, aimed at quantative treatment is in progress. Until an analysis of this kind has been carried through, one can not feel too much confidence in attempts that have been made to use long distance sonic and microbaremetric wave propagation data to deduce atmospheric temperatures at levels above the second inversion.

In addition to the theoretical approach to this problem, consideration is being given to the use of surface waves on shallow water as a model of wave propagation in the atmosphere. The velocity of surface waves whose wave length is greater than the depth of the water is a function of the depth, so that the variation of velocity with altitude in the atmosphere can be simulated on a thin sheet of water by suitable contouring of the bottom. Surface tension and visosity set at a lower limit of about 4 cm. to the wave lengths that can be used in such a model. With a water table about four feet wide simulating the atmosphere up to 50 km. a four centimeter wave length would represent a wave length in the atmosphere of about 1 mile, or a period of about fiv seconds.

Complementary Contracts:

a. Columbia University
No. W28-099-ac-82

b. University of California at Los Angeles
No. W28-099-ac-228

c. Woods Hole Oceanographic Institution
No. W28-099-ac-227
All contracts on: "Consultation and Assistance in Research on Atmospheric Acoustical Wave Propagation."

2. Project title: Development of Constant Level Balloons

Project scientist: Dr. James A. Peoples, Jr.

Summary of In-Laboratory Work:

The development of a constant level balloon was at first motivated by the needs of the acoustic upper air sounding program. As it has developed, this balloon is now a principal atmospheric probing tool in its own right. In order to develop this balloon several special devices have been invented. An Olland cycle pressure indicator, accurate to better than one millabar, has been developed. A device has been constructed which will deflate and bring down balloons in flight either by timing or by pressure activated mechanisms. A balanced flow control valve has been made which gives a constant flow of ballast material proportional to pressure change. Other accessories include a telemetering device to indicate the rate of ballast flow, minimum ballast flow, minimum pressure switches, barographs, and balloon tracking radio transmitters which can be picked up by an aircraft radio compass at a range of 100 miles or more. A sensitive intergrating vertical anemometer is now being developed which will aid in the interpretation of atmospheric oscillations.

A thorough investigation of balloon materials and fabrication methods has been conducted, and balloons have been designed suitable for use with the balisting mechanisms developed. Launching and operationsl techniques have been developed which permit the launching of balloons in winds up to 20 per hour. Good control of ascent rate and ceiling altitude has been obtained. Constant level flights of several hours duration are now routine and flights lasting up to 5 hours with pressure variations not greater then one or two milabars have been obtained. Simplified control which operate satisfactorily during the day or night are not adquate when sunset occurs during a flight. A system for maintaining constant level thru sunset has been devised and tested in a bell jar, but in actual flight tests have not yet been made. Temperature measurements have been made both inside and outside of balloons to show the affects of super-heat. Temperature measurements have also been made in instrument and battery cases during flight. Measurements to show the actual characteristics of control devices have been made on balloons in flight and simulated in the laboratory. This

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includes rate of ballast expenditure, diffusion, leakage, and stability of control.

By-product information of importance to meteorology or balloon flying techniques includes the following: Observation, measurement and theoretical analysis of high altitude atmospheric oscillations has been accomplished. These oscillations are several millibars in amplitude (as indicated on balloon baragraph traces) and the period of oscillation varies between 4 and 10 minutes. Air mass trajectories have been measured over ranges up to about 400 miles and have been indicated by the recovery of gear up to 2,000 miles from the launching point. Additional field tests on air mass trajectories are now being made.

Complementary Contracts:

a. New York University
   No. W28-099-ac-241
   "Development of Constant Level Balloon"

b. Melpar, Inc.
   No. W28-099-ac-429
   "Development of Balloon Telemetering System"